THE STORY OF

WATER IN MADRAS CITY

CORPORATION OF MAD

THE STORY

of

WATER

in

MADRAS CITY

INAUGURATION OF 30 M.G.D. RAPID GRAVITY FILTERS

by

Hon'ble Kalaignar Thiru M. KARUNANITHI

(CHIEF MINISTER OF TAMIL NADU)

ON

22—11—1969

M. A. KARIM
WATER WORKS ENGINEER

K. J. M. SHETTY
COMMISSIONER

TILL about the middle of the last century, Madras City obtained its water supply solely from shallow wells and tanks within the City which were subject to serious pollution owing to the porous nature of the sub-soil and want of proper drainage. Of the various proposals putforth for giving a protected water supply to Madras, the Government adopted the proposal of Mr. Fraser to tap water from the Kortalayer river and its tributaries, Kattangal and Busikal. According to this a masonry weir 6 feet high was constructed across the Kortalayar river at Tamarapakkam about 17 miles North-west of Madras to divert the flood waters first into the Cholavaram lake through the Upper Supply Channel and thence into the Red Hills lake through the Lower Supply Channel. The City's requirements were thereafter being drawn directly from the Red Hills tank through an open earthern channel. All these diversion works were undertaken and completed by the Government as a combined Water Supply and Irrigation Project in 1870. The Government spent Rs. 18.50 lakhs on the project and remained the owner of these sources and the City Municipality paid for the water drawn at Rupee one for a thousand cubic yards of water. The works required to convey the water from Red Hills to Madras were constructed solely by the Corporation and are being maintained by it. These works which were inaugurated in 1872 comprised of a Valve House situated at the South East Corner of the Red Hills lake and an earthern supply channel about 7 miles long to convey the water to Madras City by gravitation. At the Madras end, the channel delivered water without pumping or filtration into a masonry shaft at Kilpauk from which the cast iron mains of the City Distribution System branched off.

Several major improvements were designed and carried out by Mr. Madeley between 1914—1918, the Chief among them being:—

1. Construction of a covered underground masonry Conduit (in the place of open earthern channel) 7 miles long from the Intake Tower, called JONES TOWER (constructed in 1881) to Kilpauk with a carrying capacity of 23 million gallons per day;

2. Construction of 14 slow sand filters 200'×100' to filter and purify the water at the Kilpauk Water Works;

3. Construction of 3 pure water masonry tanks each 150'×150'×10' to store about 1.5 mil. gls. of filtered water inside the Kilpauk Water Works;

4. Installation of three high duty steam engine pumping units each capable of delivering 12,000 gallons of water per minute against a total head of 80 ft. for pumping filtered water into the elevated tank and the pumping main inside Kilpauk Water Works;

5. Laying of 48" steel pumping main for a length of 3,000 feet from Kilpauk Pumping Station to the Shaft from where the trunk mains start;

6. Remodelling, altering and extending the distribution system so as to ensure an adequate supply under sufficient pressure at all points of the distribution system.

Later on in 1923, he constructed 3 more filter beds 200'×130' each and a fourth underground filtered water tank of 2 million gallons capacity.

According to the design of Mr. Madeley these improvements were considered adequate for meeting the needs of the City for an anticipated population of 6.6 lakhs in 1961 at 25 gallons per head per day. But owing to the rapid developments of the City and the increase in the population much in excess of expectation, need for further improvements was felt in 1936 itself.

Subsequent improvements

Since then various other improvements have been carried out from time to time to augment the source of supply, and to ensure a better and more equitable distribution of water to meet the growing needs of the City which has developed for more rapidly than was anticipated in 1914 at the time of the inauguration of Mr. Madeley's scheme. The most notable amongst these are the following:—

1. Construction of a dam across the river Kortalayar and forming the reservoir known as Satyamurthi Sagar at Poondi 12 miles above Tamarapakkam Anicut to impound the water and let it down the river without surplussing over the Anicut.

2. Construction of a 2nd Conduit to carry more water from Red Hills to Kilpauk and to provide facilities for cleaning the conduit.

3. The installation of 3 electrical pumping units at Kilpauk in addition to the 3 steam engine pump sets.

4. Duplication of the 48 inches Pumping Main from the Kilpauk Pumping Station to the Shaft.

5. A separate 42 inches Trunk Main to serve South Madras.

6. Construction of 3 underground tanks of 2 mil. gls. capacity each inside Kilpauk Pumping Station.

7. Expansion in the Distribution System by laying

(*a*) 18" Feeder main to Saidapet from Trunk Main No. 8 near the junction of Cenetoph Road and Mount Road.

(*b*) 4" distribution mains in Saidapet and West Mambalam.

(*c*) 14" feeder mains for Sembium from Kilpauk Shaft.

(*d*) 4" distribution main in Sembium.

(*e*) 4" distribution main in various newly developed areas throughout the City viz. Aminjikarai, Shenoynagar, Alagappanagar, Rajah Annamalaipuram, Gandhi Nagar, Kasturba Nagar, Nungambakkam lake area, etc.

8. According to the Redesign of the City Distribution System on Zonal Basis, which is described in detail in the following chapter, Zone 1 (comprising of New Washermanpet, Tondiarpet, Royapuram, Old Washermanpet, Sanjeeviroyanpet, Singara Garden, Narayanappa Naicken Garden, Mottai Garden, etc.) is being supplied with water by a 33" C.I. pumping main separately laid from Kilpauk Water Works to Robinson Park where the water is collected in two newly constructed underground masonry tanks of 1 mil.gls. capacity each and pumped into the existing distribution system through 2 newly constructed R.C.C. Overhead Tanks of 2.8 lakh gallons each by means of newly installed electrical pumpsets 3 in number each capable of pumping 4500 g.p.m. against a head of 60 feet.

9. A separate trunk main starting with 27" dia. C.I. main and tapering down to 9" C.I. main from the Kodambakkam High Road junction with Cathedral Garden Road along Kodambakkam High Road and Arcot Road upto City Limits has been laid to supply water to Zone 8-B comprising of Choolai Medu, Kodambakkam, Akbarabad, West Mambalam, Vadapalani, etc., under the zonal scheme. It is now temporarily connected to Trunk Main No. 8 and will ultimately be connected to the Southern Headworks to be located near Prakasa Mudaliar Road, Theagaroyanagar.

10. A separate 21" cum 18" C.I. main was laid from the junction of Cenetoph Road and Mount Road to supply water to Kottur, Engineering College, Indian Institute of Technology, Palli pattu, Kalikundram, etc. This is now being fed by Trunk Main No. 8 and after the commissioning of Southern Headworks, it will form a submain branching off from the Trunk Main for Zone 8-C.

11. A separate 42" cum 30" Trunk Main has been laid for feeding Zone 5 comprising Egmore, Chintadripet, Triplicane Government Estate, etc.

12. A 12" cum 7" Sub-main for a portion of Zone 6 has been laid and put to use. This main has been temporarily connected to a branch from Trunk Main No. 8 and will be ultimately connected to the 30" Trunk Main No. 7 after commissioning of the Southern Head Works.

13. Rapid Mechanical Sand Filters of 10 m.g.d. capacity were installed inside Kilpauk Pumping Station.

14. An R.C.C. Overhead balancing tank with prestressed side-walls of 1.5 mil.gls. capacity was constructed inside Kilpauk Pumping Station.

III. Present position and proposals.

(*a*) *Sources*· At present the City is supplied with water mainly from the same source viz., Satyamurthi Sagar, Cholavaram Tank and Red Hills lake besides the infiltration galleries at Ikkadu Thangal and Sembium. The total supply that could be made daily from these sources is about 35 mil. gls. in the years of normal rainfall. This works out to an average of 17.5 gallons per head per day. The need for augmenting the sources from a perennial river like Cauvery or Krishna is being keenly felt since a long time. Pending decision on the long term proposal, a few short term proposals were also thought of which are described below:

1. Construction of Open Lined Channel from Poondi to Tamarapakkam and thence to Red Hills.

At present water stored in Poondi Reservoir is let down the river and diverted at Tamarapakkam anicut through the Upper supply and Lower supply channels to Red Hills. It is estimated that about 550 m.c.ft. of water is lost annually by percolation losses in transit. To save this loss, it is proposed to have a separate open lined channel from Poondi Reservoir to Cholavaram. The first stage covering a distance of $9\frac{1}{2}$ miles from Poondi to Tamarapakkam was taken up for execution by the Corporation in 1964 and is practically completed. Masonry conduits or R.C.C. box culverts have been provided wherever the alignment crosses water courses and runs near villages. The total length of such covered conduit is $2\frac{1}{2}$ miles while the remaining length of 7 miles is open lined channel to a height of 5 ft. i.e. for the water-way and 1 ft. of free board. The estimated completion cost is Rs. 80 lakhs. The Second Storage from Tamarapakkam to Cholavaram is proposed to be designed and carried out by the P.W.D.

2. Raising the bunds of the Red Hills lake and Cholavaram Tank.

According to this proposal, the bunds of Cholavaram Tank ~~4 feet~~ and Red Hills lake are being raised so as to increase their full tank level

~~by 8 feet~~, 4 ft. and 2 ft. respectively. This will increase the combined total storage capacity by 680 mil. cubic feet. During years of normal rainfall, Corporation will be able to draw daily an extra quantity of about 8 million gallons per day. The estimated cost of the work is Rs. 24.59 lakhs and it is being executed by Public Works Department.

3. Acquisition of Ayacut lands of Cholavaram tank and Red Hills lake.

Under this scheme all the Ayacut lands of Cholavaram Tank and Red Hills lake have been purchased to reserve the water issued for irrigation. By this about 550 mil. cubic feet of water have been made available to the City.

4. Cauvery Water Supply Scheme.

With the completion of these 3 schemes, the quantity of water drawn for Madras City can be stepped upto about 55 mil. gallons per day in years of normal rainfall. However, all these depend only on the North-East Monsoon which is unreliable. Even partial failure of rains in any one year will affect the City's Water Supply while failure for longer periods will seriously jeopardise the City's normal life. Moreover, for a metropolitan City like Madras, with major industries requiring pure water, a daily supply of 80 million gallons at the rate of 40 gallons per head per day is necessary even for meeting present needs, not to speak of future developments. To augment the City's water supply sources in a substantial way, the Government have recently taken up the scheme for bringing 40 mil. gallons of Cauvery water daily to Madras City by pumping from the Veeranam Tank. When this scheme is completed and put into commission, the Madras City Water Supply System can be said to have been placed in a satisfactory position.

(*b*) Distribution System

Redesign on Zonal Basis:

The quantity of water available being highly inadequate, the problem of equal distribution of the available water has been all the more pressing. When the water supply system was originally designed by Mr. Madeley in 1914, it was anticipated that the City would expand towards the North in future but due to several factors, such as the availability of land for building sites, and quick transport facilities, the development has been towards the south and south-west mostly. Extension of the city limits on the west and south in 1946 placed further strain on the trunk mains and submains. Though a separate trunk main for South Madras was laid and commissioned in 1965, the Expansion has outstripped even the designed capacity of this main. Moreover new housing colonies have been coming up throughout the City. Every year several miles of new distribution mains have been laid to cater

to these areas. As a result, pressures in the tail-end areas became very low. It thus became clear that the existing distribution network should be completely redesigned and this work was commenced in 1954.

After examining the capacity of the existing trunk mains, feeder mains and distribution system, the existing and anticipated pattern of development, the requirements of industries, etc., it was decided to divide the City into 9 convenient zones and to provide separate mains of adequate sizes to cater to the needs of each zone. The design was based on a supply of 25 gallons per head per day for a population of 26 lakhs in 1991, with tail and pressure of 25 to 30 feet in the distribution mains.

The total cost of the trunk mains proposed under the first stage of this scheme will be about Rs. 320 lakhs of which works costing about Rs. 200 lakhs have been carried out so far. The cost of sub-mains, feeder mains and distribution mains to be laid in all the zones will be another Rs. 500 lakhs. Design and laying of the mains have also been taken up simultaneously in stages.

Under the zonal scheme, the north-eastern and central zones will be fed by separate trunk mains and pumping mains from Kilpauk Water Works (utilising the existing mains for some zones) while the Southern zones will be fed from a separate Headworks being constructed at Theagaroyanagar. Filtered water from Kilpauk will be pumped to this Headworks using the existing trunk main No. 8, collected in underground reservoirs and pumped through an Overhead Tank into trunk mains feeding the various Southern zones. Brief details of the trunk mains proposed for each zone are as follows:

Zone No.	Municipal Division (New)	Area	Proposals for feeding the zones	Approximate cost of proposals for trunk main in lakhs of rupees
(1)	(2)	(3)	(4)	(5)
1	1 to 10, 21 to 24	Tondiarpet, Royapuram, Washermanpet.	33" Pumping Main from Kilpauk to Robinson Park in Royapuram, two underground reservoirs of 2 million gallons capacity. 2 Overhead tanks of 5.6 lakhs gallons capacity and pumping stations at Kilpauk and Robinson Park including pumping machinery and accessories.	62.52

(1)	(2)	(3)	(4)	(5)
2	11 to 20, 25 to 30, Part of 64	George Town Perambur	Existing 42" Trunk Main No. 1	Nil
3	31, 32, 41 to 45, part of 46	Sembium, Ayanavaram	Separate trunk main of sizes 33" to 16" from Kilpauk.	31.13
4	33 to 40, part of 46 47 to 50, part of 61, 62, 63 & part of 64.	Purasawalkam, Vepery, Choolai, Otteri and Kosapet.	Existing trunk main No. 3.	Nil
5	58, part of 59, part of 61, 65 to 77	Egmore, Chintadripet, Triplicane, Govt. Estate.	Separate 42" cum 30" main from Kilpauk, also utilising the existing 30" main in Harris Road and Mount Road, etc.	39.00
6	52 to 57 part of 59	Kilpauk, Chetput, Nungambakkam.	Fxisting trunk main No. 7.	Nil
	Southern Headworks at Theagaroyanagar for zones 6-A, 7, 8-B, 8-C and 9.		Three underground reservoirs of 5.3 mil. gallons capacity, Overhead tank of 1 million gallons capacity, pumping station at Kilpauk and Theagaroyanagar, inlet & outlet mains, connections to the various zonal trunk mains, etc.	79.00
6-A	60, 78 to 80, 82 to 84.	Royapettah, Thousand Lights, North Mylapore.	Separate 27" main from Southern Head works.	3.50
7	81, 85 to 89 93 to 95	Theagaroyanagar, Teynampet, South Mylapore.	Portion of existing trunk main No. 8.	Nil
8-A	Part of 45,51 part of 52 & part of 91	Shenoynagar, Arumbakkam, Aminjikarai, West Madras.	Separate Trunk Main from Kilpauk.	26.71

(1)	(2)	(3)	(4)	(5)
8-B	Part of 91, 92 & 96	Kodambakkam, Choolai Medu, West Kodambakkam.	Separate trunk main from Southern Head-Works.	14.22
8-C	97 to 100	Saidapet, Guindy, Kottur, Raj Bhavan, Indian Institute of Technology, Engineering College.	Separate 33" & 27" trunk main from Southern Headworks with branches of smaller sizes.	39.95
9	90	Adyar, Gandhinagar, Lattice Bridge, Shastrinagar, Indira Nagar.	Pumping main from Southern Headworks with underground tanks & overhead tank.	27.89

The present stage of the various zonal schemes are as follows:

Zone 1: A separate 33" pumping main has been laid from Kilpauk Water Works to Robinson Park in Royapuram for a length of about 25,000 feet. Water pumped through this main is collected in newly constructed R.C.C. underground reservoirs with a total capacity of 2 million gallons and pumped through 2 new R.C.C. overhead tanks of 5.6 lakhs gallons capacity into the existing trunk main. The cost of this first stage works in Rs. 62.52 lakhs.

Under the Second Stage, one additional 27" trunk main and 5 submains are to be laid at a cost of Rs. 26.46 lakhs. The work has been taken up recently.

Zone 3: This scheme is for laying a trunk main for sizes varying from 33" to 16" to a length of about 24,500 feet from Kilpauk Shaft to Perambur and Sembium at a cost of Rs. 31.13 lakhs. The work is nearing completion and is expected to be commissioned in the middle of 1970.

Zone 5: A trunk main with about 10,800 feet of 42" diameter and 4,750 feet of 30" diameter cast iron pipes has been laid from Kilpauk Shaft at a cost of Rs. 39 lakhs for feeding Egmore, Chintadripet and Triplicane. The main is of 42" diameter upto Harris Road Junction of Pantheon Road, where it is connected to the existing 30" main along Harries Road and is also continued on another new 30" Main. The two 30" Mains continue upto Wallajah Road Junction of Triplicane High Road. The main has been completed and commissioned.

Zone 6: A 12" cum 7" submain for a portion of this zone has been laid along Harrington Road and Vythianatha Mudali Street at a cost of Rs. 2.01 lakhs and put into use.

Southern Headworks at Theagaroyanagar:

This Headworks, is located at Prakasa Mudaliar Road, Theagaroyanagar for supplying water to the Southern Zones 6-A, 7, 8-B, 8-C and 9 of the City such as Theagaroyanagar, Teynampet, Mylapore, Adyar, Guindy, Saidapet, Kodambakkam, etc. Filtered water from Kilpauk will be pumped through a portion of the existing trunk main No. 8 by pumpsets to be erected at the Kilpauk Water Works into 3 new underground reservoirs of 5.3 million gallons capacity at Prakasa Mudaliar Road. Separate pumpsets will pump this water through an 80 feet high Overhead Tank of 1.0 million gallons capacity to the various zones. The estimate cost of the scheme is Rs. 79.00 lakhs.

Laying of 42" pumping main to a length of 3,000 feet at Kilpauk at a cost of about Rs. 8 lakhs has been practically completed. Contracts have been awarded for the supply and erection of electrical pumpsets at Kilpauk Water Works and at Prakasa Mudaliar Road, Theagaroyanagar. The underground reservoirs at the Southern Headworks have been constructed at a cost of Rs. 14 lakhs. Cast Iron Pipes and specials required for inlet and outlet mains for the underground reservoirs have been received and pipe laying works are in progress.

Zone 8-B: A trunk main of size 27" to 9" has been laid along Kodambakkam High Road and Arcot Road upto City Limites at a cost of Rs. 14.22 lakhs. This has been temporarily connected to the Trunk Main No. 8 at the junction of Kodambakkam High Road and Ranganatha Mudaliar Street. When the Southern Headworks is completed, this main will be connected to the Southern Headworks by 42" and 33" pipes.

Zone 8-C: A 33" and 27" trunk main with branches of sizes 21" to 10" is being laid from the Southern Headworks to Saidapet area at a cost of Rs. 39.95 lakhs. A 21" cum 18" main for feeding portions of zone 8-C such as Kottur, Pallipattu, Engineering College, Indian Institute of Technology, etc., has already been laid at a cost of Rs. 8.65 lakhs and temporarily connected to Trunk Main No. 8 at the junction of Mount Road and Cenetoph Road. The 21" main will be connected to the Trunk Main for Zone 8-C after the latter is completed.

CHAPTER IV

Rapid Mechanical Filters

DIFFICULTIES MET WITHIN THE SLOW SAND FILTERS :—The Kilpauk Water Works was inaugurated in 1914 with Slow sand Filter beds for the filtration of the Red Hills Water. But within a year of the opening of the Water Works, it was found that the filters were giving erratic results and large quantities of hydrogen sulphide were released in the filtered water. It was found that after storage in the shallow Red Hills Lake, the raw water was low in turbidity but contained large amounts of organic matter in colloidal form. This organic matter through complex bacterial action in the filter beds gave rise to hydrogen sulphide which imparted a bad ordour to the filtered water. Pending further investigations, the thickness of fine sand layer in the filter beds was reduced from 30" to 6" and the rate of filtration was increased from 4" per hour or 2 gallons per square foot per hour to 8" per hour. This reduced the time taken by water to pass through the filters and consequently reduced the opportunity to pick up hydrogen sulphide. Further, for cleaning the beds, the entire 6" layer of fine sand in which the organic matter was concentrated was removed, washed and replaced instead of scraping off only the top layer, adopted when the sand layer was 30" thick.

After prolonged study by experts and varied experiments, it was decided that the best method of filtering the Red Hills water would be by Rapid Gravity Filters with chemical pretreatment.

Installation of 10 Million Gallons per day Mechanical Filters:

After further deliberations, Government in 1954 sanctioned the estimate for installation of Rapid Gravity Filters (also known as Mechanical Filters) of 10 million gallons per day capacity at Kilpauk Water Works. The plant was installed by Messrs. Paterson Engineering Company, Calcutta, in collaboration with Messrs. Gannon, Dunkerley & Company (Madras) Ltd., for the Civil Works and was commissioned in the end of 1957. This enabled the Corporation to increase the daily supply to 35 million gallons to meet the ever increasing demand.

Installation of 30 million gallons per day Mechanical Filters:

As the results of filtration by the 10 million gallons per day Rapid Mechanical Filters were found encouraging, a scheme for installing additional Rapid Gravity Filters of 30 million gallons per day capacity at a cost of Rs. 79.93 lakhs was prepared by Corporation. It was sanctioned by Council and Government in October 1961. After inviting tenders contracts were entered into by the Corporation with Messrs. Paterson Engineering Co., Calcutta for supply and erection of Filter

Plant, pumpsets, switchgear, pumping main, etc., at a cost of Rs. 32 lakhs and with M/s. Gannon, Dunkerley & Co. (Madras) Ltd., Madras for construction of Civil Works to the layout design of Messrs. Paterson Engineering Co., at a cost of Rs. 40 lakhs. Construction works was commenced in February, 1963, and carried on while supplies of equipment were also made. After the construction work advanced, erection of equipment was taken up simultaneously. From the beginning of 1968, the progress of work by the Civil Contractors, Messrs. Gannon, Dunkerley & Co., Madras was very slow and they practically stopped work from April onwards. Hence after observing all the formalities their contract was terminated in July 1968 and the Company was informed that the remaining works under their contract would be executed at their risk and cost. Action was taken to call for tenders and enter into contracts for completing the remaining works. Some of the works are now in progress. The construction of chemical house for lime and the construction of masonry sludge collecting wells are being executed by Messrs. Krishna Constructions, Madras, while the works relating to completing the clarifiers 3 & 4 have been entrusted to Messrs. Kutty's Industrial Ltd., Madras. Rectification and completion of works in the filter house was carried out by Thiru A.V. Narayanaswamy. Meanwhile the completed portion of the plant is being inaugurated so that the benefits of better quality filtered water can be passed on immediately to the citizens of Madras.

Import. Features of Rapid Gravity Mechanical Filters:

The chief feature of Rapid Gravity Filters, as the name implies, is that the rate of filtration is about 45 times more than that of standard Slow Sand Filters. The other differences arise out of this. In Slow Sand Filters, the impurities in the raw water settle on the top of the filter, i.e. sand, and form a mat which performs the actual filtration. In Rapid Sand Filters, the alum floc and impurities remaining after sedimentation, forma thin layer on the surface which is much thinner and so offers less resistance to the flow of water. In Slow Sand Filters, there is no pre-treatment, while in Rapid Sand Filters chemical coagulants are added to form flocs which remove most of the suspended impurities so that only a small proportion remains to be removed by the filters. The modern trend is to concentrate more and more on improving Clarifier efficiency so that the filters actually serve only to give a final finish to the water. Cleaning of Slow Sand Filters is carried out only once a month or so by removing the sand and washing it separately while rapid sand filters are washed mechanically once in 24 to 48 hours by an upward flow of water under pressure. Due to this, rapid sand filters require about 2% of the filtered water for washing and require skilled operators. Rapid Sand Filters occupy much less space than slow sand filters but the cost of maintenance is higher.

Raw Water Sump and Pump Room:

The new 30 M.G.D. Mechanical Filter plant has been constructed in continuation of the existing 10 M.G.D. plant.

Raw water conveyed from Red Hills through the two masonry conduits is drawn into a circular masonry suction well 30 feet in diameter and 12'-3" deep. This has 2 minutes capacity for a flow of 30 million gallons per day. The 10 million gallons per day plant also has a separate suction well of 2 minutes capacity.

The Raw Water Pumphouse is a masonry structure 50' x 25' located at the eastern side of the existing 10 M.G.D. Pumphouse. There are two raw water centrifugal pumps each with a capacity of 15,800 gallons per minute coupled to 220 H.P. Slip-ring motors and one 7,000 gallons per minute (10 M.G.D.) pump coupled to a 120 H.P. motor. This ensures sufficient standbye capacity and also provides for flexibility in operation of the plant. The pumpsets are complete with switch-gear, suction and delivery pipes, reflux valves and electrically operated delivery sluice valves. Vacuum priming sets have been provided for priming these pumps eliminating foot valves which cause a large loss of head and are difficult to maintain.

A 36" cast iron pumping main for raw water has been laid from the Pump House with an inter-connection to the existing 24" Cast iron pumping main. The two mains will together convey 40 million gallons per day to the stilling and measuring chamber adjoining the Chemical House for alum treatment.

Stilling Chamber, Measuring Chamber and Chemical House for Alum:

The stilling chamber and chemical house which were constructed as part of the 10 mil. gallons per day plant were designed for handling 40 mil. gls. per day. The stilling chamber is an R.C.C. structure 20' x 19' 6" x 9' 6" with perforated baffles for reducing turbulence, followed by 15' 9" wide measuring weir which is also used to adjust the dosage of alum. A float-operated electrical raw water flow meter will work in conjunction with this weir with one indicator at the chemical house and another indicator and recorder in the pumphouse. The raw water is pre-chlorinated in the stilling chamber while alum solution is also added just before the weir. Based on the working of the 10 mil. gls. per day plant, the expected maximum dosage of chemicals will be 3 p.p.m. of chlorine and 70 p.p.m. of alum, the average doses being 2.5 p.p.m. and 50 p.p.m. respectively.

Box Conduit and Distribution Well:

From the Weir Chamber, a 36" R.C.C. pipe Line leads to the 2 Clarifiers of the 10 M.G.D. plant. For the 30 M.G.D. plant, a 4'-9" square R.C.C. box conduit 520 feet long has been constructed from the

weir chamber to the circular R.C.C. distribution well of 12 feet internal diameter. At a height of 9 feet above ground level this well widens out to a polygon from which four 3' 6" x 3' 0" R.C.C. troughs convey water to four 6 feet diameter R.C.C. inlet wells feeding the 4 Clarifiers. 36" diameter R.C.C. pipe lines laid below the floor level of the clarifiers lead from the inlet wells to the centre of each Clarifier.

Chemical House for Lime:

In addition to alum, lime is added as a coagulant aid to improve floc formation and increase filter runs. This is accomplished both by raising the alkalinity of water and by acting as a weighting agent. It has been found that for best results with Red Hills Water, lime should be added before the water enters the Clarifiers, after the formation of pinpoint floc with alum has commenced. A Chemical House for lime has therefore been proposed adjoining the central distribution well near the Clarifiers. The ground floor of this building (40' 3" x 28' 3" inside) will be used for storing lime, while the first floor houses four R.C.C. slurry tanks in which the slaked lime powder will be mixed with water to form a 10% slurry. A series of rotating cups driven by an electric motor will raise this slurry to measuring and dosing boxes where the correct quantity of lime will be drawn off, diluted further with water and discharged through pipelines into the central distribution well where it will mix with the water before entering the Clarifiers. The equipment has been designed for an average dose of about 60 p.p.m. and maximum of 85 p.p.m. of commercial hydrated lime containing 30% calcium hydroxide. Sufficient standbye capacity has been provided for the mixing tanks and dosing equipment.

Clarifiers:

The process of coagulation consists of the addition to the water of a suitable chemical known as the coagulant which forms a flocculent precipitate or floc with the natural alkalinity in the water. The finely divided suspended impurities get trapped in the floc and so settle down easily. Colloidal impurities which will not settle by themselves form larger particles by collision and adhesion which are also removed by the settling floc.

There are 4 R.C.C. axial Flow Clarifier tanks to treat a total of 30 mil. gls. per day. Each is 140 feet in diameter with a central 50 feet diameter flocculation compartment. A central R.C.C. Pillar 5 feet diameter supports the rotating bridge which carries the flocculator and scraper mechanisms.

The floor slopes down towards the centre with a depth of 13 ft. of water at the outer edge and 20 feet at the centre.

Raw water mixed with chemicals is admitted at the bottom of the flocculation compartment through four 1' 3" x 2' 6" ports in the central pillar. This compartment is provided with four sets of rotating paddles which impart a gentle agitation to the water so as to increase the adhesion of floc particles by collision while guarding against break up of already formed floc. The paddles are suspended from a mild steel bridge which also rotates for the full benefit of the rotating paddles to be felt over the entire flocculation chamber. As the water rises through this chamber, the newly formed floc particles will impinge on the heavier particles of floc settling down from the upper layers, thereby resulting in adhesion and accretion of floc particles. By the time the water reaches the top, the bulk of the heavier accreted floc particles will have a chance to settle down. The supernatant flocculated water with the balance of wellformed floc will be collected in a 2' x 2' 6" R.C.C. trough through 157 nos. of 4" square submerged orifices in the flocculator side wall and discharge through eight 21" vertical steel pipes to the bottom of the Clarifying zone in a tangential direction. Due to the tangential entry the water flows spirally while rising gradually to the top, thereby increasing the parth of travel. The floc particles settle to the bottom while clarified water which contains only a small portion of the impurities originally present in the raw water is collected at the top in another R.C.C. trough 5' x 4' 6" through a series of 352 nos. 2" diameter orifices around the entire periphery of the clarifier side wall.

The detention time (flow through period) works out to about 40 minutes in the flocculation and 3.5 hours in the clarifier (settling) zones. The surface loading in the settling zone works out to 565 gallons per square foot per day or about 3.7 feet per hour. As this is a low rate, the clarifiers can be overloaded by 25% without any difficulty. The velocity in the various pipes and orifices in the clarifier tank is kept below 1 foot per second to avoid breaking up of floc.

The clarifiers provided for the 30 mil. gls. per day plant feature certain improvements over those of the 10 M.G.D. plant. In the old clarifiers, water is admitted around the periphery at the top of the flocculation zone, moves downwards and outwards into the settling zone and rises upto the collecting orifices at the top of the clarifiers. In the new clarifiers water is admitted at the bottom of the flocculation zone, rises upto the top and is again directed to the bottom of the settling zone to rise to the top where it is finally collected. Thus the path of travel is longer and the direction of flow in both compartments is against the direction of settling particles, so that the smaller flocs have more opportunity to collide with settling particles and form bigger, quick settling flocs. Flocculated water is introduced tangentially at the bottom of the settling zone, again helping to increase the length of flow path.

The sludge collected at the bottom of the flocculating and clarifying zones will be scraped into a central pit in the former and three pits at the lower edge in the latter by means of scraper blades attached to the rotating bridge and discharged through cast iron pipes. The removal of sludge from these pits will be done automatically by valves remotely controlled by the rotating bridge. The bridge completes one revolution in about 40 minutes so that each of the three 6" diameter sludge pipes leading from the clarifier zone will be opened once in 40 minutes and the 8" pipes from the flocculation zone will be opened once in 20 minutes. The duration of opening can be adjusted so that sludge of 10% to 15% slurry concentration can be drawn off, reducing loss of water to a minimum.

Clarified water from each clarifier is led into a 6 ft. diameter R.C.C. outlet well and conveyed through R.C.C. pipe line to the filter house. The pipe lines from Clarifiers 3 and 4 which are far away are of 36" diameter while those from Clarifier No. 1 and 2 are of 24" diameter. The velocity in these pipes is kept below 2 feet per second to avoid breaking up of any remaining floc.

Filter House:

This is a masonry building constructed on the northern side of the existing 10 m.g.d. filter house and abutting it, so that the entire structure housing the 24 filter beds of 40 m.g.d. capacity forms one unit with continuous access from one end to the other. The filters in both portions are arranged in two rows with the operating gallery, pure water channel, wash water channels, outlet control chambers, wash water pipe lines, valves, etc., in the middle.

The effluent from the clarifiers contains a small portion of impurities originally present in the raw water floc particles. It passes into the western arm of the 4'-6" x 7'-0" influent channel constructed around the filter house. Three 36" R.C.C. pipe lines are laid underneath and across the new filter beds to equalise levels in the eastern and western portions of the influent channel. Water is drawn from the influent channel through inlet penstocks into the filter beds.

There are 18 filters for the new 30 m.g.d. plant. Each filter is 36' x 25' and is divided into two halves 16' x 25' by a 3' 0" wide central gutter so that the filtering area of each bed is 800 sq.feet. The filter loading for 30 m.g.d. works out to 87 gallons per sq. foot per hour and this can be increased to 100 gls. per sq. foot per hour without affecting the quality of water. As it was felt that by suitable pre-treatment of the raw water, the filtration rate can be increased to 150 gls. per sq. foot per hour, thereby increasing the output of the plant, the laterals, pipes inside the filter house and valves have been designed for this higher rating.

In each filter .... ~~nos. of~~ 3" diameter perforated A.C. pipes laterals are laid in four rows, each of 28 pipes and connected to two collecting troughs at the bottom of the filter beds. Over these pipes the filter media is placed to a total height of 45" as follows from bottom to top:

3" thickness of 2" to 1½" gravel.

3" thickness of 1½" to 1/2" gravel.

4" thickness of 1/2" to 1/4" gravel.

4" thickness of 3/8" to 1/8" gravel.

6" thickness of 1/4" to 1/10" grit.

25" thickness of 16/32 gauge fine sand free from Calcium.

Filtered water flows through the laterals and collecting troughs and passes into R.C.C. control chambers (inspection boxes) constructed outside the filter beds, where float operated rate of flow controllers are provided. The designed rate of flow can be set manually by a rate setter whereupon the float controlled outlet valve maintains it automatically. The outlet valve is also automatically throttled when the filter is put back into use after washing so that the filter rate is slowly increased to the required rate of flow in 15 to 20 minutes. This slow start is essential as initially, after the filters are washed, the filter bed has not got the thin top layer of floc particles which aids filtration. Another float is provided inside the filter which automatically closes down to about 18" over the filtering surface thereby preventing the filter being drained dry.

The various pipes and valves controlling the flow of filtered water, wash water, waste water, etc., are located adjacent to the control chambers. The pipe work is so arranged that each small filter unit of 16' x 25' can be used and washed independently. All the control valves of the 30 m.g.d. portion are pneumatically operated from a control table for each filter bed. The rate of flow and loss of head indicators and indicator lamps showing the position of opening of the valves are also fixed on the control table. A compressor and receiver, located in the filter house basement, supplies air under pressure for operating the valves. In the old 10 m.g.d. plant the valves are hydraulically operated, again from a central control table, high pressure water for operation being supplied by a separate pump.

From the control chambers, filtered water flows into a covered 8' x 4' pure water channel along the longitudinal axis of the filter house and then into the filtered water conduit constructed outside the filter house.

An entrance hall with a basement floor housing wash-water pumps and an R.C.C. overhead tank has been provided for the new building similar to that in the existing 10 m.g.d. plant. There are two wash water pumps each capable of pumping 1250 gallons per minute of filtered water into the overhead tank against a head of 45 feet coupled to 30 H.P. slipring motor with suction and delivery pipes, electrically operated delivery valves, etc. One of the pumps is a standbye. A 15" cast iron main from the overhead tank which divides into two 15" branches, conveys wash water to the 2 rows of filters. The branches are connected at the ends so that there is a complete loop around the inner side of the filters. The wash water pipe lines of the 10 m.g.d. and 30 m.g.d. plants are interconnected, with valves on the mains leading from the overhead tank, so that either or both tanks can deliver water for washing any one of the 24 beds.

Washing of the filter beds is by air agitation followed by water which uses less water than plain water wash at high velocity. There are two air compressors with 25 H.P. motors capable of compressing 103 cubic feet per minute against a back pressure of 75 pounds per square inch with 4 steel receivers each of 300 cubic feet capacity, in the 10 m.g.d. plant. These will be sufficient for the 30 m.g.d. plant also, with the addition of one more compressor. Compressed air is delivered to the filters at 15 pounds per square inch by a 6" C.I. pipe line. For washing, the filter media is first agitated by admitting compressed air for 2 minutes to agitate the bed uniformly and break up the impurities. Then wash water is admitted at 10 gallons per square foot per minute (18" rise) for about 4 minutes to expand the bed and wash away the impurities into the waste water troughs. These have been provided as an extra item in the 30 m.g.d. plant. The troughs are fixed 21" above the level of the sand bed to prevent sand particles being washed away. There are three 1' 3" wide troughs for each half of the filter bed, so that wash water does not have to travel more than about 3 feet horizontally before being removed. This ensures uniform removal of impurities over the entire area of the filter beds.

Since the wash water troughs are fixed slightly above the level of the sand bed, some portion of wash water with impurities will remain on the filter beds and would normally need a disproportionately large flow of water to remove by the process of progressive dilution. These impurities are removed without wastage of water by PATERSON'S patented quick discharge syphons of which 12 are fitted to each filter bed in both the old and new filters. After washing for about 4 minutes at 10 gallons per square foot per minute, the flow of wash water is reduced to 3 to 4 gallons per square foot per minute for about 4 minutes and at the same time the syphons are brought into operation. These remove the waste water down to about 3" over the filter bed.

Filtered Water Conduit:

This is a masonry conduit of size 5' 0" x 4' 6" with a carrying capacity of 25 million gallons per day from the new portion of the Filter House upto its junction with the 5'-0" x 4'-0" conduit coming out of the old Mechanical Filters which will also carry 20 mil. gls. per day. From there a single conduit has been newly constructed of size 6'-6" x 4'-4½" with a maximum capacity of 50 mil.gls. per day upto the existing filtered water conduit feeding the underground filtered water reservoirs, at the Water Works. Just before this junction, the new filtered water conduit crosses the two raw water conduits feeding Kilpauk Water Works. In this portion, the filtered water is conveyed through two rows of 48" Cast Iron pipes which were tunnelled below the raw water conduits without interrupting the flow of raw water.

Disposal of Sludge and Wash Water:

Two longitudinal wash water channels 6' x 3' have been provided in the filter house on either sides of the Pure Water Channel. These have been given a slope from the centre towards the two ends. Wash water from 12 filters (dealing with 20 m.g.d. flows out of the southern end of the filter house through a 36" R.C.C. pipe line into a 50 feet diameter R.C.C. sludge collecting well which is part of the 10 m.g.d. plant. Sludge from the two clarifiers of the 10 m.g.d. plant also flows into this well. There is a circular pump-room over the sludge well from which two electrically driven pumpsets of 7.5 H.P. pump out the sludge and wash water through a 12" R.C.C. pipeline.

Sludge from two of the 4 new clarifiers will flow into a 12' dia. R.C.C. well and from there, through a 24" R.C.C. pipe line into a new 30' dia. masonry sludge well (common sludge well) being constructed near clarifier No. 3, in which the sludge from Clarifier No. 3 will also be directly connected. Sludge from Clarifier No. 4 will be collected in another 30' dia. sludge well near Clarifier No. 4 and this sludge well will be connected with the common sludge well by a 36" pipe line. Wash water from the remaining 20 M.G.D. filters will be let out at the northern end of the new filter house and flow through a 36" dia. R.C.C. pipe line into a 30' dia. masonry collecting well to be constructed north of the sludge well near Clarifier No. 4 and connected with that sludge well through a 36" dia. R.C.C. pipeline. By this arrangement all the three collecting wells are in interconnected. A masonry pump room of 16' dia. is to be constructed adjoining and south of the common sludge well from where the mixture of sludge and wash water is proposed to be pumped out for disposal through another 12" R.C.C. pipeline.

Design ~~for~~ Criteria for Civil Works:

The load on foundations has been restricted to 1 tonne per square foot except in deeper portions where loading has been allowed upto 1.5 tonnes per sq.foot. The load on brickwork in cement mortar 1:3 has been restricted to 6.5 tonnes per square foot. For R.C.C. work, the following stresses have been adopted:

Concrete	$1:1\frac{1}{2}:3$ in contact with water	1:2:4 mix.
Compression in bending.	850 lbs. per Sq. inch	750 lbs. per Sq. inch.
Compression Direct	680 lbs. per sq. in.	600 lbs./sq. in.
Shear	85 lbs. per sq. in.	75 lbs./sq. in.
Bond	110 lbs. per sq. in.	100 lbs. per sq. in
Steel in tension and shear	10000 lbs. per sq. inch	1800 lbs. per sq. inch
Modular Ratio	15	15

Copper strip expansion joints have been provided for roof slab in Filter House and box conduit, and copper strip and G.I. Sheet construction joints have been used wherever such joints occured in side walls of Clarifiers, Overhead Tank and collecting well.

Government of India were pleased to grant import permits for Actuators required for electrically operated valves.

All foundations have been laid with $1\frac{1}{2}$" Blue Granite Jelly in cement mortar 1:3:6.

Quantities of Materials used:

Steel	...	860 tonnes
Cement	...	4,841 tonnes
3" stock bricks	...	30,41,000 nos.
$1\frac{1}{2}$" blue granite jelly	...	1,60,000 cubic feet
3/4" do	...	2,48,000 cubic feet
River sand	...	2,67,000 cubic feet
3/4" brick jelly	...	11,200 cubic feet
3/4" flat tiles	...	2,79,000 nos.
36" R.C.C. hume pipes	...	1,665 R.ft.
24" R.C.C. do	...	325 R.ft.
12" R.C.C. do	...	2,150 R.ft.

All the doors and windows are of standard quality. Steel frames were supplied by well-known manufacturers. Internal wiring and lighting for all the buildings are being carried out by the Corporation Electrical Department.

Cost:

The total estimated cost of the scheme as sanctioned by Government for installing 30 million gallons per day capacity Rapid Gravity Mechanical Filters is Rs. 79.93 lakhs. Due to several deviations and alterations found necessary during execution and also due to increase in cost of cement, steel, machinery, etc., the completion cost will be higher. A revised estimate was prepared including the cost of other works not included in the two main contracts and the cost of the revised estimate comes to Rs. 91.57 lakhs, and that has been sanctioned by Government in G.O. Ms. No. 1662-H dated 22-10-68.

Inspection of Works and Government Grants:

Detailed plans and estimates relating to all Water Supply improvement works are scrutinised and recommended by the Chief Engineer (Public Health Engineering and Municipal Works). The Superintending Engineer (Public Health), Madras Circle, is the Inspecting Officer for all water supply scheme works which are eligible for half grant from the Government. This scheme for Rs. 91.57 lakhs was sanctioned by Government as an improvement scheme in the III Five Year Plan period eligible for 50% loan and 50% grant. While the eligible loan has been granted in stages on applications made by the Corporation, grant is being paid every year to the extent of 50% of the value of works completed as certified by the Inspecting Officer.

The Water Works Department is responsible for the maintenance of the water supply system in the City and for all water supply improvement works. The Water Works Engineer, Thiru M.A. Karim, B.E., is assisted by 2 Assistant Engineer on the maintenance side and three Executive Engineers and 8 Assistant Engineers in regard to all water supply improvement works executed out of loans and grants.

APPENDIX I

Facts at a Glance

SATYAMURTHI SAGAR:

Completed in	...	1944
Capacity at full tank level	...	2,500 mill.c.ft.
Water spread at full reservoir level	...	12½ sq. miles
Total catchment area	...	787 sq.miles
Full reservoir level above M.S.L.	...	+137.50
Lowest drawable level	...	+105.00
Distance from Madras	...	37 miles

TAMARAPAKKAM ANICUT:

Length of anicut	...	626 ft.
Height of anicut	...	6 ft.
Width at crest level	...	6 ft.
Crest level	...	+72.40
Bed level	...	+66.40
Distance from Madras	...	17 miles

UPPER SUPPLY CHANNEL:

Head sluice;

15 Vents	...	5'-0" x 5'-7"
Sill level	...	+66.40

UPPER SUPPLY CHANNEL:

		miles	chains
Length of channel	...	8	14
Width at bottom on average		45 ft.	
Side slopes	...	1:1	
Depth at tull supply	...	7 feet	
Carrying capacity	...	1220 Cusecs	

CHOLAVARAM LAKE:

Capacity at full tank level	...	525 mill.c.ft.
Water spread at full tank level	...	2 sq. miles
Catchment area	...	11 sq. miles
Full tank level above M.S.L.	...	+60.12
Lowest drawable level	...	+46.64
Distance from Madras	...	14 miles

LOWER SUPPLY CHANNEL:

Head sluice;

9 Vents	...	3'-0"×4'-0"
Sill level	...	+46.64

LOWER SUPPLY CHANNEL:

		Miles	Chains
Length of channel	...	2	50
Width at the bottom	...	30 ft.	
Side slopes	...	$1\frac{1}{2}$: 1	
Depth at full supply	...	7 feet	
Carrying capacity at F.S.L.	...	900 Cusecs	

RED HILLS LAKE:

Capacity at full tank level	...	2185 mill.c.ft.
Water spread at full tank level	...	7 sq. miles
Catchment area	...	23 sq.miles
Full tank level above M.S.L.	...	+46.17
Lowest drawable level	...	+29.2
Distance from Madras	...	10 miles

MASONRY CONDUIT:

Old conduit	...	5'-0"×4'-3"
Bed fall	...	1 foot per mile
Carrying capacity	...	23 mill. gallns. a day
New conduit	...	6'-6"×4'-3"
Bed fall	...	1 foot per mile
Carrying capacity	...	31 mill.glns. a day

FILTER BEDS:

Slow sand Filters	...	14 Nos. 200' x 100' 3 Nos. 200' x 133'

FILTERED WATER TANKS:

Filtered water tanks	...	3 Nos. 1.4 mill.glns. each 1 No. 2 mill.glns. 3 Nos. 2, 8 mill.glns. each

PUMPSETS:

Electric pumpsets	...	3 Nos. of 1.2 mill. glns. per hour against a head of 80 feet.
Electric pumpset	...	4 Nos. of 0.6 mill. glns. per hour against a head of 80'

PUMPING MAINS:

48" diameter mild steel pumping main	...	1
48" Cast Iron pumping main	...	1

DISTRIBUTION MAINS:

Cast Iron Trunk mains of sizes varying from 42" to 14"	...	8 Nos.

TOTAL LENGTH OF TRUNK MAINS & SUB-MAINS UPTO 31-3-69:

9"-48"	...	119.35 Kilo Metres.

TOTAL LENGTH OF DISTRIBUTION MAINS UPTO 31-3-69:

$2\frac{1}{2}$"-8"	...	1008.88 Kilo Meters.

APPENDIX II

Completed Works

Statement showing the expenditure on Water Supply Capital Works upto 31-3-1969.

Particulars of work		Cost Rs. in lakhs
'Old Works' in existence prior to 1914 comprising of Valve House at Red Hills, Open earthern Supply Channel leading to the City and Distribution System	...	23.00
'New Works' opened on 17th December, 1914 viz. In-take Tower at Red Hills, underground conduit, Slow Sand Filters, Filtered Water tanks, Pumps, Elevated Tank, Pumping main, alteration and extensions to the Distribution System including the 3 Filters and one Filtered Water Tank added in 1923	...	66.00
Further improvement and extensions to Distribution System	...	52.54
Improvement to Red Hills Lake	...	0.48
Waste Detection Meters	...	1.50
Installation of Booster	...	1.20
Installation of additional Booster	...	5.40
Installation of 2 High Duty Electrical Pumps at the Kilpauk Pumping Station	...	3.00
Construction of Satyamurthi Sagar	...	66.17
Water Supply to Theagaroya Nagar	...	3.96
Water Supply to City Extensions	...	0.90
Construction of Second Conduit	...	50.90
Separate Trunk Main for South Madras (Trunk Main No. 8)	...	37.76
Duplication of Pumping Main from Kilpauk Pumping Station to Shaft	...	6.83
Installation of the 3rd Electrical Pump at KPS	...	2.00
Installation of Rapid Mechanical Filters of 10 m.g.d. capacity at Kilpauk Pumping Station	...	28.39
Construction of 2 Nos. additional Underground Filtered Water Tanks at Kilpauk Water Works	...	13.85
Emergency water supply works carried out during the drought years of 1950, 1951 and 1952	...	18.57
Acquisition of land west of Kilpauk Water Works	...	4.55
Laying a 33" Pumping main for North Madras constructing underground reservoirs of 2.55 mil.gls. capacity and 2 R.C.C. Overhead Tanks of 5 lakh gallons capacity, Pump Houses at Kilpauk Pumping Station and Robinson Park and Installation of electrical pumpsets	...	60.45
	C/o.	447.45

Particulars of works	Expenditure upto 31-3-69	Expenditure from 1-4-69 to 30-9-69
	Rs. in lakhs	
B.F.	... 447.45	...
1. Feeder Main to Saidapet (18")	... 3.48	...
2. Feeder Main to Sembium	... 4.07	...
3. Water Supply to West Mambalam	... 2.86	...
4. Remodelling public fountains in the City	... 4.00	...
5. Providing water supply to Aminjikarai, Ayanavaram and Kodambakkam	... 2.20	...
6. Water Supply to Saidapet	... 2.78	...
7. ,, Sembium	... 2.27	...
8. ,, Alagappa Nagar layouts	... 1.73	...
9. Repairs to Ist Conduit	... 2.59	...
10. Replacement of old and worn out Fire Hydrants	... 2.09	0.01
11. Laying distribution mains in various layouts roads in the City (V to XIII) and Water supply to Annamalaipuram)	... 18.01	0.07
12. Construction of Research Laboratory at K.P.S.	... 0.81	...
13. Construction of Overhead Tank at K.P.S. (1.5 million gallons)	... 13.86	0.03
14. Construction of 1 No. underground filtered water tank at K.P.S.	... 12.75	...
15. Laying trunk main for Zone 8-B	... 11.95	...
16. Water Supply to Southern Higher Technological Institute at Guindy	... 7.19	...
17. Providing water supply to Indian International Trade & Industries Fair	... 3.52	...
18. Laying Trunk Main for Zone 5	... 35.77	0.24
19. Water Supply to areas adjacent to Harrington Road in Zone 6	... 1.07	...
20. Change over from 5 K.V. to 11 K.V. Transformers at Kilpauk Pumping Station	... Nil	0.06
	580.45	0.41

APPENDIX III

List of Works in Progress

Name of the work	Estimated cost in lakhs
1. Laying Distribution mains in various layouts in the City (Scheme V to XIII) ...	26.83
2. Installation of Rapid Mechanical Filters of 30 m.g.d. at Kilpauk Water Works ...	91.57
3. Laying a separate 42" cum 30" Trunk Main to Zone 5 comprising Egmore, Chintadripet and Triplicane ...	39.00
4. Laying a 36", 27" and 24" Separate Trunk Main for Zone 3 comprising Perambur, Sembium and Ayana-... varam	31.13
5. Construction of open lined channel from Poondi to Red Hills including acquisition of lands ...	64.00
6. Laying Trunk Main for Zone 8-C ...	35.95
7. Southern Head Works for feeding Zones 6-A, 7, 8-B, 8-C and 9 at Prakasa Mudaliar Road, T.Nagar ...	78.00
8. Installation of Diesel Generators and Pumpsets to replace the existing steam engine at K.P.S. ...	27.34
9. Feeder main and Distribution mains in areas 1 & 2 of Zone 8-B ...	15.15
10. Laying Trunk Mains and Sub-mains for Zone 1 ...	26.46
11. Laying Trunk mains for Zone 8-A ...	26.36

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154,688 :36